DOCUMENT RESUME

ED 141 756 CS 003 502

AUTHOR Klein, Marvin L.
TITLE A Selective Consideration of the Development of Logical Reasoning Skills, Grades K-12, and Some Implications for Reading Teachers.
PUB DATE May 77
NOTE 29p.; Paper presented at the Annual Meeting of the International Reading Association (22nd, Miami Beach, Florida, May 1977)

EDRS PRICE MF-$0.83 HC-$2.06 Plus Postage.
DESCRIPTORS *Abstract Reasoning; Child Development; Developmental Stages; Educational Needs; Elementary Secondary Education; Literature Reviews; *Logical Thinking; *Reading Comprehension; *Reading Instruction; Reading Skills; *Thought Processes

ABSTRACT

Ability to reason clearly and efficiently is perhaps the single most important learning objective common to all subjects and to all aspects of the schooling situation. In order to design an effective reading comprehension program, teachers and program planners must assess children's logical abilities. This discussion provides a review of some of the literature concerning logical thinking and outlines several reasoning patterns: causality, negation, conditionality, and so on. Implications for the reading teacher suggest that decisions regarding teaching and measuring be made on the basis of workability and not on assumptions of reasoning ability, that decisions concerning instructional approaches and materials selection be based on a solid understanding of the reasoning tasks required in stories and exercises, and that formal reasoning-skills instruction take place. (KS)

****
* Documents acquired by ERIC include many informal unpublished *
* materials not available from other sources. ERIC makes every effort *
* to obtain the best copy available. Nevertheless, items of marginal *
* reproducibility are often encountered and this affects the quality *
* of the microfiche and hardcopy reproductions ERIC makes available *
* via the ERIC Document Reproduction Service (EDRS). EDRS is not *
* responsible for the quality of the original document. Reproductions *
* supplied by EDRS are the best that can be made from the original. *
****

ED141756

U S DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

A SELECTIVE CONSIDERATION OF THE DEVELOPMENT OF LOGICAL REASONING SKILLS, GRADES K-12, AND SOME IMPLICATIONS FOR READING TEACHERS

by

MARVIN L. KLEIN
Wisconsin Department of Public Instruction
126 Langdon Street
Madison, Wisconsin 53702

PERMISSION TO REPRODUCE THIS COPYRIGHTED MATERIAL HAS BEEN GRANTED BY

Marvin L. Klein

TO ERIC AND ORGANIZATIONS OPERATING UNDER AGREEMENTS WITH THE NATIONAL INSTITUTE OF EDUCATION. FURTHER REPRODUCTION OUTSIDE THE ERIC SYSTEM REQUIRES PERMISSION OF THE COPYRIGHT OWNER.

A Paper Presented at the 22nd Annual Convention of the International Reading Association, Miami Beach, Florida, May 4, 1977.

CS 003 502

Marvin L. Klein
Wisconsin Dept. of Public Instr.
126 Langdon Street
Madison, WI 53702

A SELECTIVE CONSIDERATION OF THE DEVELOPMENT OF LOGICAL REASONING SKILLS, GRADES K-12, AND SOME IMPLICATIONS FOR READING TEACHERS

Ability to reason clearly and efficiently is perhaps the single most important learning objective common to all subjects and, indeed, to all aspects of a schooling situation. Even a cursory examination of curriculum materials in areas such as social studies, math, science or the language arts suggest a number of objectives which call upon the learner to "compare and contrast," "determine cause-effect relationships," "detect or perceive specious logic," "infer a reasonable conclusion," "develop a generalization based upon examination of given data." We could go on at some length delineating curricular objectives which are more common to the varying processes of reasoning than to the subject matter per se.

James Moffett (Student-Centered Language Arts and Reading, K-13) observes that the bulk of reading comprehension objectives for most reading programs reflect the same attributes as those mentioned above. Most are the kind of thinking and reasoning skills required by any illiterate Australian aborigine negotiating his outrigger off some ocean reef in the South Pacific. They tend to be objectives that are not only not specific to reading comprehension but in some instances not even specific to language. (p. 123)

Regardless of whether or not we concur with Moffett, it is now quite clear that more authorities such as Frank Smith, Kenneth Goodman, et al, are defining reading comprehension as a hypothesizing operation in which we are constantly attempting to "reduce uncertainty" to some degree. And few, if any of us, would want to disagree with a premise which would suggest that other things being equal, a logical reasoner is more apt to be a better comprehender than one who is not a logical

reasoner. Further, if course outlines, curriculum guides, scope and sequence descriptions of major commercial reading programs and attendant reading materials are any indication, there is major reason to assume that the importance of logical reasoning facility is implicit in all sub-domains of the reading comprehension area.

In fact, one's ability to perceive and mentally act upon propositions, propositional relationships, data-warrant moves and other like logical operators and operations could well be the most important capacity to be brought to bear in the comprehension of language in any mode.

In order to design an effective reading comprehension program, or for that matter even teach a single lesson in reading then would seem to require that we know where a child is and where he is going in terms of logical abilities.

From the standpoint of formal reasoning skills, this is not a particularly easy task to consider. Part of the difficulty rests in the varying perceptions of what constitutes a reasonable logical model for analysis of those skills, e.g., Aristotelian logic or modern logic? At the present time, for instance, utilization of a classical Aristotelian logic is popular with reading authorities as a model for developing measurement and/or diagnostic test objectives and items to be used in reading programs. There is substantial reason, however, to consider the viability of a modern (symbolic) or propositional logic as a more powerful tool for both examining the growth of reasoning skills in the learner and designing evaluation and diagnosis tools for the reading program. Piaget's developmental work, for instance, is rooted in a modified propositional logic. And, the base of Chomsky's generative-transformational approach to language production and attendant analysis is modern logic.

There are also problems in deciding, with any degree of precision, the kinds of relationships which hold between production and/or comprehension of oral discourse, written language and cognition. This author, for instance, has done

informal comparisons of selected learner performances on reading comprehension tests where scores on specific inferential comprehension objectives were low, with performance on nonprint cognitive ability tasks (qua Piagetian measures on Some-All Classification, Class Inclusion, and Seriation) requiring cognitive skills many would presume to underly performance on print-oriented counterparts. Results suggested that many readers haven't the reasoning ability/s to perform the cognitive tasks necessary for the reading act to begin with. The reading tests used then tell us little, if anything, with any diagnostic precision about these performers.

Further, if there are differences in the kinds of mental energy expenditures employed in varying modes of discourse, then the attendant confounding of one by the other/s in research procedures places hardships on many findings. Was it processing of oral instructions or the task at hand which produced the result? Was it abstractness of the task per se in the testing situation or the logical complexity of the problem? And, many similar questions might be raised.

It is not the purpose of this paper either to document such difficulties or to suggest strategies for alleviating them. But rather, it is hoped that the reader will keep in mind the continuing need to consider the diversity of topics and approaches which fall under the rubric of reasoning and consider what follows as a selective attempt to identify specific principles and/or ideas which appear to be of interest to the teacher of reading. With the varying modes of discourse, alternatives within both inductive and deductive reasoning skills, and the range of linguistic and semantic variables which impinge, it seems highly unlikely that any sort of parsimonious model of logical reasoning skill study can be fruitful. And the following is pulled from a wide range of research models.

With then a "nonparsimonious" perspective, one important point we can pretty safely make is that <u>reasoning skills are not merely a function of intellectual development</u>. Many gross reasoning skills do evolve through the developmental

years of the learner. The child learns to classify, to abstract, to perform the mental tasks required of things such as Piaget's binary operations sets through the stage of formal operations. She or he will grow into an ability to conceptualize, to generalize, to hypothesize.

However, many of the most important reasoning skills will not develop without formal instruction. It appears unlikely, for instance, that learners will develop the ability to detect fallacious conclusions in a deductive mode given reasonable premises. (Klein, 1973; Roberge, 1969, 1970, 1971; Ennis, 1970; Paulus, 1967; Howell, 1965, 1967; Ennis and Paulus, 1965) The matter is especially troublesome when syllogisms* or syllogistic structures are provided without suggested potential conclusions. Learners are much more capable of selecting a valid conclusion from an array of invalid options than simply projecting such a conclusion in an open ended situation.

The entire area of causality is a difficult one requiring specific formal attention. Ability to discern varying senses of 'because'---causal as in "He is a doctor because he wants to serve humanity;" justification for knowing as in "He is a doctor because I saw him perform an operation;" and tautologous as in "He is a doctor because he has MD after his name"---plagues most individuals of all ages. (Ennis and Paulus, 1965+) The matter is complicated further in the primary grades where 'because' is used as a coordinating conjunction rather than in any of the above senses. (Dale, 1976; Brown, 1973; Cazden, 1972; Piaget, 1969)

Expressions of conditionality seldom appear in oral discourse until about the age of 10 or 11. (Loban, 1963; Piaget, 1928) Even more troublesome, however, is that most individuals fail to perceive the various restrictions which impose upon antecedent-consequent relationships at any age. Many high school 12th graders, for instance, are willing to assert that antecedent and consequent clauses may be

*A syllogism is a deductive argument form consisting of one or more premises and a necessarily entailed conclusion.

transposed without alteration, and at the same time, without affecting causal relationship, e.g., "If it rains, we'll not have a picnic" means the same, according to such reasoning, as "If we do not have a picnic, it rained." (Klein, 1973; Shapiro and O'Brien, 1970)

In a like vein, adults as well as children fail generally to effectively distinguish between necessary and sufficient conditionals in either oral or written discourse, e.g., "If the weather is nice, we'll have a picnic" and "Only if the weather is nice will we have a picnic" are equated. (Klein, Shapiro and O'Brien) Given such confusion, it appears a reasonable inference to conclude that syntactically different but semantically equivalent propositional assertions in every day language are even more difficult for readers to comprehend, e.g., consider the expression, "We must send more troops in if we are to win the war." Is it a necessary or sufficient proposition? The issue is critical, for a necessary conditional only establishes prerequisites for achieving the consequent. It leaves open the possibility, or even the probability, that additional steps, procedures, or conditions must be met as well as those explicitly stated. Whereas the sufficient conditional proclaims sufficiency in the antecedent. It turns out then that our friend who says, "We must send more troops in if we are to win the war" does <u>not</u> promise us that troops are enough and, hence, does not assure us that troops alone are what we really need. They are <u>not</u> sufficient but are necessary.

Based only on the few principles of logical reasoning presented here---determining valid conclusions, dealing with causality and it's attendant language facilitators such as 'because,' and comprehending and utilizing conditionality, the 'if-then's,' 'have to's,' 'must's' and 'only if's' so crucial to comprehension of most proposition-bearing utterances or written expressions---we can see that critical reasoning skills for the comprehension of assertive writing are not likely to just evolve. They must be taught and they must be taught in a direct fashion, not one tangential to all else, if they are to be learned.

A second important projection we can make is that although there are some reasoning and/or reasoning related attributes which are directly tied to overall cognitive development as described by developmentalists such as Piaget, it is not a moot question as to whether a so-called "general reasoning facility" is reasoning stage dependent or whether it is in fact complexity dependent. In fact, there is considerable reason, in a formal logic sense, to suggest logical complexity in many reasoning operations more fundamental than stage of cognitive development. (Ennis, 1976; Roberge, 1976; Kodroff and Roberge, 1975; et al) For instance, the author's 6 year old niece effectively dealt with each of the following problems recently,

A) "There are two little girls, Mary Ann and Barbara. They live in a town with two schools, the Red School and the White School. One of the girls goes to one of the schools. The other girl goes to the other school.

Mary Ann does not go to the Red School. Which school does she go to?

Which school does Barbara go to?

B) "If the weather is really nice today, we'll go on a picnic.

It sure looks like the weather's nice today.

What does that mean we'll do?

C) "If we have a picnic, we'll have blueberry pie.

We aren't having blueberry pie so...?"

In a formal logic sense, Jennifer inferred the appropriate deductive conclusions in a disjunctive syllogism (A), an example of the logical principle of detachment in an alternation propositional logic. (B) is a formal Modus Ponens or application of detachment in a conditional propositional logic. And, example (C) is a Modus Tollens or particular contraposition in a conditional propositional logic. These informal assessment findings with Jennifer are in keeping with the more

formal research findings of researchers such as Donaldson, 1963; Hill, 1960; et al. Children at a very young age appear to be able to handle a simplified propositional logic when the content and language are in their experience range.

However, the same logical reasoning principles can easily be made far more difficult by utilizing a wider range of logical operators in the problems. For example,

A) Given: P, Q, ... = a variable representing single propositional component of an assertion

Thus, "Joe hit the ball" = H

B) Given: $\longrightarrow$ = if-then

Thus, "If you study, you will pass" = S $\longrightarrow$ P

C) Given: v = either-or

Thus, "We'll either play ball or pitch horseshoes" = B v H

D) Given: $\sim$ = no, not

Thus, "Joe didn't study" = $\sim$S

E) Given: $\cdot$ = and

Thus, "He studied and he passed = S $\cdot$ P

F) Given: $\therefore$ = therefore, hence

Thus, 1) P v Q

2) $\sim$P

$\therefore$ 3) Q

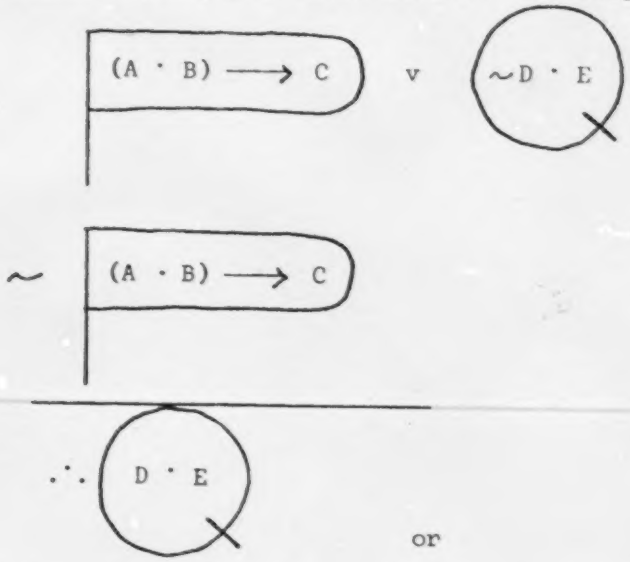
then Jennifer's first problem (disjunctive syllogism) was: P v Q

$\sim$ P

$\therefore$ Q

"Either the Red School or the White School. Not the Red. Therefore, the White."

However, we may also construct the following disjunctive syllogism:



or

"Either, if you go to the Red School and play ball, you'll have fun or you don't work here and eat berries for desert. It's not true that if you go to the Red School and play ball, you'll have fun. So, you don't work here and eat berries for desert."

Though an absurd example, it is valid, and it does illustrate how logical complexity can be introduced into the same logical principle and make it cumbersome, if not impossible, for most of us.

In the Cornell Critical Thinking Project, where considerable effort was given to the maintenance of constancy and general clearness in procedural and research design variables, the following logical principles were tested at selected grade levels:

RELATIONAL PRINCIPLES OF CONDITIONAL LOGIC

1) Detachment: (Modus Ponens)

$$\begin{array}{l} P \longrightarrow Q \\ P \\ \hline \therefore Q \end{array}$$

2) Full Transitivity: (Hypothetical Syllogism)

$$\begin{array}{l} P \longrightarrow Q \\ Q \longrightarrow R \\ \hline \therefore P \longrightarrow R \end{array}$$

3) Particular Transitivity: (Combined Hypothetical Syllogism and Modus Ponens)

$$\begin{array}{l} P \longrightarrow Q \\ Q \longrightarrow R \\ \underline{P} \\ \therefore R \end{array}$$

4) Particular Contraposition: (Modus Tollens)

$$\begin{array}{l} P \longrightarrow Q \\ \underline{\sim Q} \\ \therefore \sim P \end{array}$$

5) Full Contraposition: (Transposition Equivalency)

$$\underline{P \longrightarrow Q}$$
$$\therefore \sim Q \longrightarrow \sim P$$

6) A) Biconditional Forward: Positive Detachment

$$\begin{array}{l} P \text{ if and only if } Q \\ \underline{P} \\ \therefore Q \end{array}$$

B) Biconditional Reverse: Positive Detachment

$$\begin{array}{l} P \text{ if and only if } Q \\ \underline{Q} \\ \therefore P \end{array}$$

C) Biconditional Forward: Negative Detachment

$$\begin{array}{l} P \text{ if and only if } Q \\ \underline{\sim P} \\ \therefore \sim Q \end{array}$$

D) Biconditional Reverse: Negative Detachment

$$\begin{array}{l} P \text{ if and only if } Q \\ \underline{\sim Q} \\ \therefore \sim P \end{array}$$

(FORMALLY INVALID MOVES)

7) Particular Conversion: (Fallacy of Affirming the Consequent or FAC)

$$\begin{array}{l} P \longrightarrow Q \\ \underline{Q} \\ \therefore P \end{array}$$

8) Full Conversion:

$$\underline{P \longrightarrow Q}$$
$$\therefore Q \longrightarrow P$$

9) Particular Inversion: (Fallacy of Denying the Antecedent or FDA)

$$\begin{array}{l} P \longrightarrow Q \\ \underline{\sim P} \\ \therefore \sim Q \end{array}$$

10) Full Inversion:

$$\underline{P \longrightarrow Q}$$
$$\therefore \sim P \longrightarrow \sim Q$$

The findings are summarized in Tables 1 and 2:

TABLE 1

*PERCENTAGES OF STUDENTS SATISFYING THE CRITERION FOR MASTERY OF CERTAIN CONDITIONAL-LOGIC PRINCIPLES

	GRADE			
	5	7	9	11
N	102	99	80	78
Mean CA (years-months)	10-9	12-9	15-4	16-11
Mean IQ[a]	108	117	110	109
Principle:				
1. Detachment	51	56	66	62
2. Full Transitivity	25	45	40	58
3. Particular Transitivity	26	52	53	58
4. Particular Contraposition	30	41	35	35
5. Full Contraposition	34	40	35	33
6. Biconditionality	23	40	46	40
7. Particular Conversion	2	3	4	3
8. Full Conversion	2	5	11	19
9. Particular Inversion	3	6	5	12
10. Full Inversion	NOT TESTED			

[a] Lorge-Thorndike or California Test of Mental Maturity.

TABLE 2

PERCENTAGES OF PRIMARY STUDENTS SATISFYING THE CRITERION[a] FOR MASTERY OF CERTAIN CONDITIONAL LOGIC PRINCIPLES[b]

	GRADE		
	1	2	3
N	30	28	29
Mean CA (years-months)	6-5	7-6	8-5
Mean IQ[c]	107.1	109.7	106.8
Principle			
Particular Transitivity	13	29	45
Particular Contraposition	40	64	62
Particular Conversion	0	11	7
Particular Inversion	20	43	31

[a] The test used here is different from that used for previous Table 1. Intertable comparisons of absolute percentages (rather than trends) are not warranted.

[b] Ennis, et al.

[c] Wechsler Intelligence Scale for Children.

* As cited in R. H. Ennis, "An Alternative to Piaget's Conceptualization of Logical Competence," Child Development, 1976, 47, 903-919.

Similar kinds of findings are to be noted in numerous other studies. (Roberge, 1971, 1976; Barratt, 1975; Berzonsky, Weiner, and Raphael, 1975; Siegler and Liebert, 1975; Klein, 1973; Bart, 1971; Neimark and Slotnick, 1970; Shapiro and O'Brien, 1970; Paulus, 1969; Miller, 1968; Howell, 1967; Peel, 1967; Gardiner, 1965; Case and Collinson, 1962; Lovell, 1961; Hill, 1960; Maw, 1959; Hyram, 1957; Maier, 1936; Burt, 1919; et al) Note especially the minimal increments across grades in all logical principles with the possible exception of transitivity. Percentages of students at the 11th grade even here though still seem low at 58 percent or so. Note, too, the especially poor performances on invalid inferences mastery. What little increment accrues still leaves considerable wanting.

There does not appear to be a substantive developmental growth of most of these deductive reasoning skills across grades and years as a function of maturing. Further, an examination of the logical principles involved in the Ennis, Paulus work suggests that logical complexity could well account for many of the results. Negation in transposition operations, logical operator shifts in the implication rule, and logical chaining required in DeMorgan's Theorem could be obvious factors in the various logical principles they researched.

On the other hand, however, there are particular and general reasoning skills, as well as a number which are at least indirectly tied to reasoning facility, which apparently are functions of stage of development. They appear to be attributes of those general cognitive facilities mentioned earlier which evolve in all normal humans and lead to ability to abstract, conceptualize, hypothesize---in gross senses, at least.

For example, the general preoperational thought of the learner (prior to 7 years or so) tends to be "transductive" in nature, neither deductive nor inductive; but, instead, a simple matter of drawing direct causal links by physical, geographical or whimsical association--a sort of argumentum post hoc ergo propter hoc gone wild.

All things can be connected in virtually any way. This is often expressed in animistic terms--air is alive and conscious, the sun and moon accompany us on walks, most things have live internal powers, everything has been made for people (some attributes of animism appear not to be stage dependent!), clouds start moving by themselves, the sun comes from clouds, the boat goes on the lake because it wants to. (Piaget, 1928, pp. 180-186) In fact, many of the attributes of sentence structure that children "violate" in their early language through 7 or 8 years of age, like the adult grammar rule that animate verbs require animate nouns, are in terms of the child's cognitive world, reasonable uses of language. In later grades, 3rd, 4th and on up, the metaphoric quality of the youngster's talk is only present as intentional metaphor, and thus is infrequent. Logical expressions begin to appear, but language reflecting anything like serious hypothetical reasoning will not appear until at least 11 or 12 years of age. (Klein, 1977; Loban, 1976; Piaget, 1928) With the onset of concrete operations, however, ability to draw data-warrant relationships, to make generalized inferences in at least a quasi-inductive way, and to perceive the necessity implicit in deductive processes should be accessible to the learner.

We should note too that Jennifer, our precocious 6 year old propositional reasoner of a short time back--the one who performed well with both disjunctive and conditional syllogisms--was totally confused on a class inclusion task,

"If Honesdale is in Pennsylvania, and Pennsylvania is in the United States, then is Honesdale in the United States?"

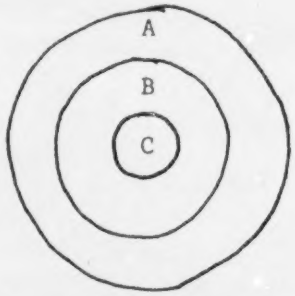
Response - "No."

Question - "Why not?"

Response - "'cause Honesdale is a town and Pennsylvania is a state!" (???)

It is important to consider that drawing a valid inference in a disjunctive syllogism does <u>not</u> require that the individual understand whether the disjunctive

assertion is either inclusive or exclusive. Negation of one propositional component as the syllogism requires leaves only one alternative anyway. However, the class inclusion task requires an understanding of subset relationships--if A is in B and B is in C, then A too must be in C, e.g.



And, a perception of joint set membership requires additional understandings. Ability to perceive such relationships should be well established in a fundamental way for most by the stage of concrete operations.

Seriation or ordering too presents serious problems for the preoperational and early operational child--up through 7+ years. A number of important studies have shown how young children and beginning readers in early school years comprehend easier when there is temporal and grammatical correspondence in utterances or sentences, e.g., "After you feed the dog, you may play" is preferred to "You may play after you feed the dog." (Clark and Stafford, 1969; Hatch, 1969; Clark and Clark, 1968)*

Piaget (1969) has pointed out that rather complex deductive operations are required to coordinate sustained interrelated temporal concepts. In the context of story sequences, research indicates that children in the early grades have less difficulty in arranging a series of brief episodes than they do in constructing a single story or episode in which the same individual must appear in different situations. In a number of recent studies (Brown, 1976; Brown and French, 1976; Bronckhart and Sinclair, 1973; Ferreiro and Sinclair, 1971) exploring children's

---

*Follow-up work by Hatch reviewing the practice of constructing such sentences in published beginning readers by various authors with these research findings in mind yielded disappointing results. (Hatch, 1969)

comprehension of various temporal series attributes, preoperational children seem to unduly favor the end result of an action sequence. While older children prefer the actual order of events, children through 5 years of age begin their verbal description with the terminal event. When attempting to physically reconstruct a logical sequence of pictures, kindergarten subjects choose the terminal item first. The young child seems primarily interested in the outcome of events rather than prior conditions.*

Ferreiro and Sinclair (as cited in Brown and French) offer a nice and delightful example:

> A child aged 5 years gave the following correct description of a series of two events--"The girl cleaned the boy, afterwards the boy went up to the top of the stairs." Asked to describe the same sequence starting with the boy's actions, the child tried, "The boy went upstairs and after, the girl cleaned him." Prompting revealed that the child knew this to be incorrect, so the experimenter showed him the events again with no greater success. Finally, in response to a question as to whether it was possible to reverse the description, he replied, "No, you've got to start with the girl. If you start with the boy, the boy goes upstairs first, afterwards the girl cleans him." (p. 939)

Remember Alice in Wonderland:

> Alice - "The cause of lightning is the thunder---No, no! I mean the other way 'round."
>
> Red Queen - "When you've once said a thing, that fixes it, and you must take the consequences."

In a related area, ability to see the semantic equivalence of syntactically different constructs is troublesome even through the stage of concrete operations. Piaget notes,

> Another and very different case of syncretism which we discovered is equally suggestive from the point of view of the analytical weakness shown by the child whenever there is any question of connecting propositions or even of understanding words independently

---

*A number of language development studies show similar linguistic preferenee for predication as the most important part of sentences. Note, too, Vygotsky's research on the nature of inner speech and it's function in the learner's cognitive development. (Vygotsky, 1962)

> of the schemas in which they are enveloped. The child is given a certain number of easy proverbs and a certain number of corresponding sentences jumbled together, but each meaning the same thing as one of the given proverbs. He is then asked to find the connection. Now up till the age of 11-12 the child chooses the corresponding sentence more or less at random, or at any rate by means of accidental and purely superficial analogies. (Piaget, 1928, pp. 231-232)

It is possible via the application of certain logical principles to transform the syntactic character of assertions to logically equivalent counterparts. For example, an 'if-then' conditional such as "If you study, you will pass" may be converted to a different conditional by reversing the roles of antecedent and consequent and, at the same time, negating each. Hence, "If you study, you will pass" and "If you didn't pass, you didn't study" are equivalent. Likewise by application of the implication rule, "If you study, you will pass" can be changed to the disjunctive assertion, "Either you didn't study or you did pass" without doing disservice to the meaning of the original conditional. Like operations can also lead to conjunctives. Most learners, however, tend not to recognize the potential of expressing like logical ideas in alternative syntactic forms until the developmental stage of formal reasoning. Even 4th graders tend not to sense the possibility of syntactically unlike reciprocals. Although formal stage reasoners will not always accept the logical reciprocity of specific assertions, they seem to at least allow that such logical operations are permissible. (Klein, 1973; Piaget, 1928)

As a final area of mention, we should note generally the role of negation in logical reasoning development. In some respects, this is one of the easiest areas to address. At the risk of oversimplifying, the data here are generally clear---the introduction of negation into the language in any fashion or form increases complexity and makes processing more difficult. It has in fact been so dominant in its character as to lead some, such as Boucher and Osgood, to at least imply that an essential antagonism to negation is rooted in the innate faculties of man. Specifically, Boucher and Osgood (1969) posit a "Pollyanna Hypothesis" which asserts

that "there is a universal tendency to use evaluatively positive (E+) words more frequently, diversely, and facilely than evaluatively negative (E-) words." (Boucher and Osgood, 1969, p. 1) However, others prefer to treat the notion in a less dramatic fashion. Geach (1958) asserts, for instance, that negation is a linguistic concept and cannot be derived from sense experience or other directed sources any more than any other logical constant.

A great deal of the work on negation has been done by P.C. Wason. (1959+) Wason, for instance, found that Ss take longer to respond to false statements or to negated statements than to affirmative or true statements. Ss also require significantly longer time for explicit negatives than for implicit negatives in a timed task, suggesting the importance of the semantic factor in the processing of negatives. (Wason, 1963; Eifermann, 1961)

In a similar study, Miller (1962) found that Ss take longer to match affirmatively expressed sentences with their negative counterparts. Apparently a response latency to negative statements is some function of grammatical structure.

Greene (1961) found that natural semantic function pairs are easier to deal with than unnatural pairs and manipulation of context can affect difficulty. In this regard, Greene suggested,

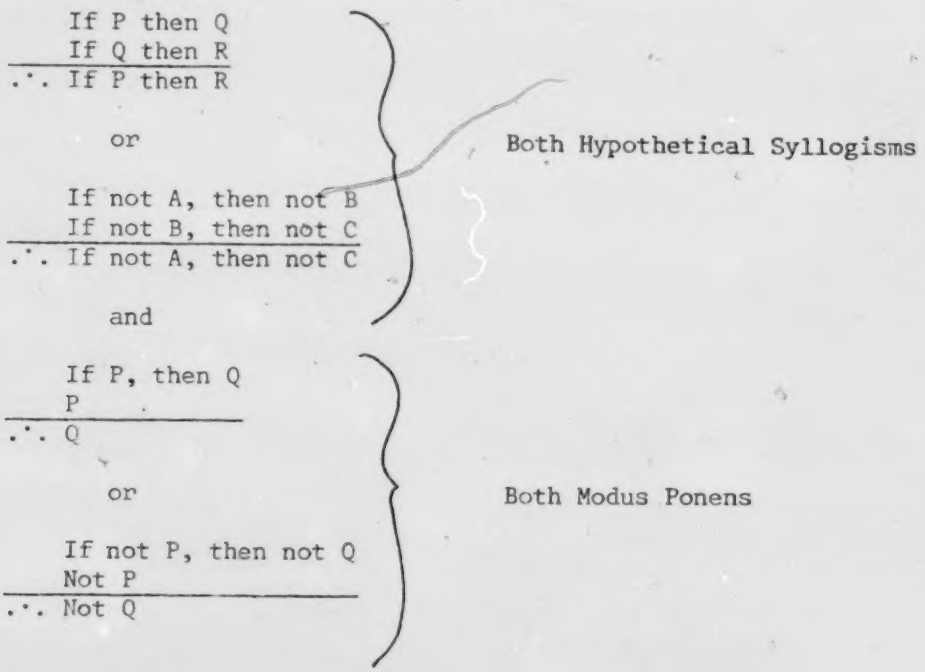
> The negative carries out an active meaning change process on a prior affirmative assertion. An affirmative, on the other hand, implies nothing about its converse. (Greene, 1961, p. 18)

We can note as well that the negative presents some problems in language acquisition. Miller, Chomsky, Slobin and Menyuk all note negativity and its related uses as one of the more complex and difficult features in language acquisition and development.

As one would expect, interpretation of the major studies in logical reasoning support and even further suggest negation as an important aspect of complexity in deductive reasoning. Using Modus Ponens, Modus Tollens and class syllogistic forms,

Roberge (1969, 1970), with Ss sampled from grades 4, 6, 8 and 10, found that negation in the major premise of the syllogism has marked effect on performance. There appeared to be a stronger influence in class reasoning than in conditional, although negation seriously affected both. Roberge observed as well that the Fallacy of Denying the Antecedent (Inversion Fallacy) was troublesome at all grades. Hill (1960) found in studying 6, 7, and 8 year olds that introduction of negation presented additional difficulties in deductive reasoning, as did Paris (1975).

It is also of interest in view of this complexity factor in the comprehension of negation in logical reasoning, to consider its role in the acquisition of certain logical reasoning abilities. Kodroff and Roberge (1975) and Howell (1965) note, for instance, that contraposition (Modus Tollens) is mastered later than the Hypothetical Syllogism. In relation to this, one may note that although negation may appear as attribute within the Hypothetical Syllogism and Modus Ponens form, it is only in the Modus Tollens that it is an explicit part, e.g.



But,

If p, then Q
Not Q

∴ Not P

or

If not P, then not Q
It's not the case of not Q

∴ It's not the case of not P

Negation is required in the Modus Tollens. (This can present some problem when interpreting reasoning research data. In a given study of logical reasoning skill, to what extent are Ss response a function of the logical relations of the explicit assertions of the Modus Tollens, and to what extent are they merely a function of the presence of negation?)

It is also true, as researchers such as Youniss and Furth (1967) point out, that the presence of the negative in a conditional reasoning task forces one from the use of a conditional as a possible single instance or literal one-to-one manifestation of an idea to a use of it as a class generalization with positions on nonmembership in a class.

Such a use would suggest that the ability to hypothesize about the unobserved world is instrumental in negated conditional use. In this regard, Roberge (1971) observed in a study of adults that although there appeared to be a significance in the form of the major premise as a factor in deductive reasoning, there were nonsignificant differences for affirmative as opposed to negative conclusions. Further, the mean number of errors for items with negated conclusions was stable regardless of the form of the major premise. This appears to be in keeping with earlier studies such as Howell (1965) and Ennis and Paulus (1965) where researchers observed a later mastery of contrapositive argumentative forms than for non-negated forms such as the Hypothetical Syllogism.

A FEW IMPLICATIONS FOR THE READING TEACHER

1) One cannot assume direct psychological links between the attributes of any given logical model used to assess or teach reasoning skills and those mental energy expenditures which actually take place in the thinking act. Of course, the same holds true for any reading skill sequence design and the mental operations which take place while one reads. We assess and teach from those models or approaches which appear to reflect more reasonable relationships to language use. However, all such models are constructs which reflect certain arbitrary attributes. This is something which must be kept in mind by the teacher at all times. Decisions on teaching and measuring approaches ought to be made on grounds of workability and not upon a priori notions of what constitutes the varying reasoning skills of inferential comprehension.

It is not true, for instance, that all learners function either inductively or deductively. Children in beginning reading programs are transductive. No matter how carefully or orderly we design a reading lesson with these children, there seems little reason to assume that they internalize the skill being taught via the mental route that we used in shaping the lesson plan. To this extent, inductive teaching need not always be better than deductive. In fact, the necessity of the data-warrant link in deductive reasoning in some respects bears closer resemblances to transductive reasoning than does induction. A conclusion can necessarily entail from a single premise; hence, the one-to-one sort of correspondences which seem to be attributes of transductive operations are hinted at in deduction. Further, the premises-conclusion chain is typically shorter, an attribute of transductive operations also.

At the very least, this should suggest that we approach initial instruction tasks with an open mind and something less than certitude in our belief systems about correspondences between how we design and sequence our instructional steps and how our beginning students actually learn to read.

2) We often assume a greater range of linguistic and cognitive abilities in our students than we have a right to expect. Many logical reasoning skills and linguistic facilities do not develop till well into adolescent years.

On the other hand, we often fail to credit learners, especially those in the primary grades, with those propositional asserting and chaining skills which they are capable of.

Decisions about instructional approaches and materials selection must be rooted in a solid understanding of the reasoning tasks required in the stories and exercises as well as in our own instruction. Consideration of instructional materials, for instance, should allow for systematic examination of:

a) Negation in the materials. How prevalent is it? (Even comparative counts of negatives can be helpful.) What are the forms of negation employed? How are negatives used in diagnostic tests?

b) Temporal-grammatical correspondences. Have the authors of materials for the primary grades attempted to control for this matter somewhat? Is there temporal-grammatical correspondence in well over 50 percent of the instances of appearance in first and second grade basals?

c) Causality. How are causal assertions posited in the reading? Conditionals? Disjunctives? How are semantically dense logical cues such as 'because,' 'if-then,' 'must,' 'have to,' 'therefore,' 'hence,' 'then,' etc. used?

d) Hypothetical expression? How prevalent is suppositional language in the reading? What about contrary-to-fact subordinators such as "In spite of the fact that," or "Even though X happened," or "Although Y might take place'?

Criteria for text selection, as well as supplementary reading materials, must include far more reference to specific reasoning skills and attributes than are currently attended to.

3) Reasoning skills instruction must take place. Decisions about the content of the reading comprehension aspect of our programs must be made with the understanding that improved inferential comprehension might well be contingent upon direct formal instruction in logical reasoning. Reasoners who are unable to identify fallacious conclusions and attendant faulty reasoning processes in deductive arguments are not likely to be able to detect specious reasoning in written materials. Reasoners who do not tune in to the subtle but important distinctions in the semantic loads of key cue terms, phrases and assertions in thinking operations cannot be expected to infer appropriate generalizations in reading tasks where such expressions play a fundamental role. And, reasoners not cognizant of the relations which hold between alterations of syntax and the propositional impact of such alterations are not likely to bring to bear the critical and thoughtful approach to reading which is so fundamental to efficient comprehension.

Yet few if any of us are going to acquire such abilities simply through the maturing process. Even those reasoning skills which do develop as a general function of cognitive maturing are not refined without conscious effort. The subtlety, nuance, and sharpness of critical reasoning do not just happen. A conscious, formal, time-allotted curriculum component and corresponding instructional commitment to improved reasoning skill development is crucial. Yet, this seems not to be done in a serious fashion in either commerically prepared reading programs or in locally developed curriculum.

A review of currently available programs in reading in fact yielded most disappointing results. Activities in classification are to be found scattered throughout most early reading programs (and in some science programs such as AAAS). And seriation activities are addressed in a limited fashion throughout most published reading programs--ordering events by chronology seems to be the only sort of seriation activities many know, however. Beyond this the potential

of propositional logic--both class and sentential--has been largely ignored. Observations about the nature of inductive and deductive processes are even confounded at times by incorrect descriptions of their respective attributes. Certainly, serious efforts to treat this area have not been forthcoming.

It will require some effort, but it just might be well worth it for improved reading comprehension.

REFERENCES

Barratt, B. B., "Training and Transfer in Combinatorial Problem Solving: The Development of Formal Reasoning During Early Adolescence," Developmental Psychology, 1975, 11, 700-704.

Bart, W. M., "The Factor Structure of Formal Operations," British Journal of Educational Psychology, 1971, 41, 70-77.

Berzonsky, M. D., A. S. Weiner, and D. Raphael, "Interdependence of Formal Reasoning," Developmental Psychology, 1975, 11, 258.

Bonser, F., The Reasoning Ability of Children of the 4th, 5th, and 6th School Grades, New York: Columbia University, 1910.

Boucher, J., and C. Osgood, "The Pollyanna Hypothesis," Journal of Verbal Learning and Verbal Behavior, 1969, 8, 1-8.

Bronckhart, L. P., and H. Sinclair, "Time, Tense, and Aspect," Cognition, 1973, 2, 107-130.

Brown, A. L., "Semantic Integration in Children's Reconstrcution of Logical Narrative Sequences," Cognitive Psychology, 1976, 8, 247-262.

Brown, A. L., and L. A. French, "Construction and Regeneration of Logical Sequences Using Causes or Consequences as the Point of Departure," Child Development, 1976, 47, 930-940.

Brown, R., A First Language: The Early Stages, Cambridge: Harvard University Press, 1973.

Burt, C., "The Development of Reasoning in School Children," Journal of Experimental Psychology, 1919, 5, 68-77, 121-127.

Case, D., and J. M. Collinson, "The Development of Formal Thinking in Verbal Comprehension," British Journal of Educational Psychology, 1962, 32, 103-111.

Cazden, C., Child Language and Education, New York: Holt, Rinehart and Winston, 1972.

Clark, H., and E. Clark, "Semantic Distinctions and Memory for Complex Sentences," Quarterly Journal of Experimental Psychology, 1968, 20, 129-138.

Clark, H., and R. Stafford, "Memory for Semantic Features," Journal of Experimental Psychology, 1969, 80, 326-334.

Corley, G., An Experiment in Teaching Logical Thinking and Demonstrative Geometry in Grades Six Through Ten, unpublished doctoral dissertation, Peabody College for Teachers, 1959.

Dale, P. S., Language Development: Structure and Function, New York: Holt, Rinehart and Winston, 1976.

Donaldson, M., A Study of Children's Thinking, London: Tavistock, 1963.

Eifermann, R., "Negation: A Linguistic Variable," Acta Psychology, 1961, 18, 258-273.

Ennis, R., "An Alternative to Piaget's Conceptualization of Logical Competence," Child Development, 1976, 47, 903-919.

Ennis, R., "Conditional Logic and Primary Children," unpublished paper, American Education Research Association, March, 1970.

Ennis, R., and D. Paulus, Critical Thinking Readiness in Grades 1-12, Phase I: Deductive Reasoning in Adolescence, Ithaca: Cornell University, 1965.

Ferreiro, E., and H. Sinclair, "Temporal Relations in Language," International Journal of Psychology, 1971, 6, 39-47.

Gardiner, W., An Investigation of Understanding of the Meaning of the Logical Operators in Propositional Reasoning, unpublished doctoral dissertation, Cornell University, 1965.

Geach, P., Mental Acts, London: Routledge and Kegan Paul, 1958.

Greene, J., "The Semantic Function of Negatives and Passives," British Journal of Psychology, 1970, 61, 17-22.

Halpern, E., "The Effects of Incompatability Between Perception and Logic in Piaget's Stage of Concrete Operations," Child Development, 1965, 36, 491-497.

Hatch, R., "Four Experimental Studies of Syntax in Young Children," Inglewood, California: SWRL for Research and Development, TR11, October, 1969.

Hatch, R., "The Syntax of Four Reading Programs Compared with Language Development of Children," Inglewood, California: SWRL for Research and Development, TR21, December, 1969.

Haygood, R., and L. Bourne, Jr., "Attribute and Rule-Learning Aspects of Conceptual Behavior," Psychological Review, 1965, 72, 175-195.

Hill, S., A Study of the Logical Abilities of Children, unpublished doctoral dissertation, Stanford University, 1960.

Howe, E., "The Associative Structure of Qualifiers," Journal of Verbal Learning and Verbal Behavior, 1966, 5, 147-155.

Howell, E., "An Experiment to Improve the Reasoning Ability of Seventh Grade Students," Philadelphia: Temple University, 1967.

Howell, E., Recognition of Selected Inference Patterns by Secondary School Mathematics Students, unpublished doctoral dissertation, University of Wisconsin, 1965.

Hyram, G. H., "An Experiment in Developing Critical Thinking in Children," Journal of Experimental Education, 1957, 26, 125-132.

Inhelder, B., and J. Piaget, The Growth of Logical Thinking, Basic Books, 1958.

Klein, M. L., "Inferring from the Conditional: An Exploration of Inferential Judgments by Students at Selected Grade Levels," doctoral dissertation, University of Wisconsin-Madison, 1973.

Kodroff, J. K., and J. Roberge, "Developmental Analysis of the Conditional Reasoning Abilities of Primary-Grade Children," Developmental Psychology, 1975, 11, 21-28.

Loban, W., Language Development: Kindergarten Through Grade Twelve, Urbana: National Council of Teachers of English, 1976.

Loban, W., The Language of Elementary School Children, Champaign: National Council of Teachers of English, 1963.

Lovell, K., A Follow-up Study of Inhelder and Piaget's "The Growth of Logical Thinking," British Journal of Psychology, 1961, 52, 143-153.

Lunzer, E. A., "Problems of Formal Reasoning in Test Situations," Society for Research in Child Development, 1965, 30, 19-43.

Maier, N., "Reasoning in Children," Journal of Comparative Psychology, 1936, 21, 357-366.

Marks, L., and G. A. Miller, "The Role of Semantic and Syntactic Constraints in the Memorization of English Sentences," Journal of Verbal Learning and Verbal Behavior, 1964, 3, 1-5.

Maw, E., An Experiment in Teaching Critical Thinking in the Intermediate Grades, unpublished doctoral dissertation, University of Pennsylvania, 1959.

Mehler, J., "Some Effects of Grammatical Transformations on the Recall of English Sentences," Journal of Verbal Learning and Verbal Behavior, 1963, 2, 346-351.

McMahon L., Grammatical Analysis as Part of Understanding a Sentence, unpublished doctoral dissertation, Harvard University, 1963.

Miller, E. H., "A Study of Difficulty Levels of Selected Types of Fallacies in Reasoning and Their Relationships to the Factors of Sex, Grade Level, Mental Age, and Scholastic Standing," Journal of Educational Research, October, 1955, 49, 123-129.

Miller, G., "Some Psychological Studies of Grammar," American Psychology 1962, 17, 748-762.

Miller, W. A., The Acceptance and Recognition of Six Logical Inference Patterns by Secondary Students, unpublished doctoral dissertation, University of Wisconsin, 1968.

Moffett, J., and B. Wagner, A Student Centered Language Arts and Reading Curriculum, Boston: Houghton Mifflin and Company, 1976.

Neimark, E., and N. Slotnick, "Development of the Understanding of Logical Connectives," Journal of Educational Psychology, December, 1970, 61, 451-460.

Paris, S., Propositional Logical Thinking and Comprehension of Language Connectives: A Developmental Analysis, The Hague: Mouton, 1975.

Paulus, D., A Study of Children's Abilities to Deduce and to Judge Deductions, unpublished doctoral dissertation, Cornell University, 1967.

Peel, E., "A Method for Investigating Children's Understanding of Certain Logical Connectives Used in Binary Propositional Thinking," British Journal of Mathematical and Statistical Psychology, 1967, 20, 81-92.

Piaget, J., The Child's Conception of Physical Causality, New Jersey: Littlefield, Adams and Company, 1966.

Piaget, J., The Child's Conception of Time, London: Routledge and Kegan Paul, 1969.

Piaget, J., Judgment and Reasoning in the Child, New York: Harcourt, Brace and Company, 1928.

Roberge, J., "A Study of Children's Abilities to Reason with Basic Prineiples of Deductive Reasoning," American Educational Research Journal, November, 1970, 7, 583-596.

Roberge, J., "Developmental Analyses of Two Formal Operational Structures: Combinatorial Thinking and Conditional Reasoning," Developmental Psychology, 1976, 12, 563-564.

Roberge, J., "Negation in the Major Premise as a Factor in Children's Deductive Reasoning," School Science and Mathematics, November, 1969, 69, 715-722.

Roberge, J., "Some Effects of Negation on Adults' Conditional Reasoning Abilities," Psychological Reports, December, 1971, 29, 839-844.

Shapiro, B., and T. O'Brien, "Logical Thinking in Children Ages Six Through Thirteen," Child Development, September, 1970, 41, 823-829.

Siegler, R. S., and R. M. Liebert, "Acquisition of Formal Scientific Reasoning by 10- and 13-Year-Olds: Designing a Factorial Experiment," Developmental Psychology, 1975, 11, 401-402.

Vygotsky, L., Thought and Language, Cambridge: The M. I. T. Press, 1962.

Wason, P. C., "The Contexts of Plausible Denial," Journal of Verbal Learning and Verbal Behavior, 1965, 4, 7-11.

Wason, P. C., "The Processing of Positive and Negative Information," Quarterly Journal of Experimental Psychology, 1959, 2, 92-107.

Wason, P. C., "Response to Affirmative and Negative Binary Statements," British Journal of Psychology, 1961, 52, 133-142.

Wason, P. C., and S. Jones, "Negatives: Denotation and Connotation," British Journal of Psychology, 1963, 54, 299-307.

Youniss, J., and H. Furth, "Attainment and Transfer of Logical Connectives in Children," Journal of Educational Psychology, 1964, 55, 357-361.

Youniss, J., and H. Furth, "The Role of Language and Experience on the Use of Logical Symbols," British Journal of Psychology, 1967, 58, 435-443.